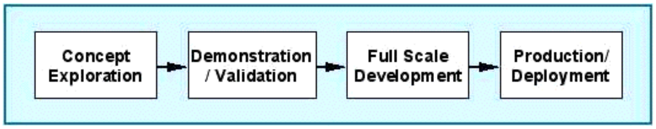
Overview of the HF/S process.

Human factors/Safety (HF/S) technology includes the methods, models, hardware, software, firmware, courseware, information management techniques, operating procedures, documentation, system design features, and data for integrating the human into a Coast Guard system. HF/S is predicated on the technological opportunities associated with:

- defining and designing for the role of the human in complex systems
- simulation and modeling of crew workloads for manning estimation
- controlling workloads
- knowledge generation: to reduce cognitive workloads on CG personnel, emphasis must be placed on requirements for generation and processing of knowledge as well as information, wherein
- advanced human-machine interfaces through human-centered design
- CG design methods and data
- techniques to enhance productivity
- techniques for improving the quality of life at work with attention to the quality of services and facilities afforded the crew with respect to habitability, medical care, administrative and personal support, environment control, personal safety, cultural and educational opportunities, and physical security to achieve the objective of reduced life cycle cost with improved crew performance, productivity, and safety.

The HF/S process, as discussed here, is imbedded in the overall USCG systems acquisition process. This four phase process is as follows. Details for each of these phases can be reviewed by clicking on the appropriate phase.



The HF/S Process

Major HF/S requirements. The major requirements to be imposed on HF/S are: 1) personnel considerations and requirements must influence system design; 2) HF/S must have a central role in the affordability assessment; 3) HF/S must drive the system risk assessment; 4) HF/S must maximize the quality of acquired products; 5) HF/S must attend to requirements for concurrent engineering; 6) the HF/S process must address the emphasis on use of commercial products and standards; 7) the HF/S process must include requirements for prototyping, simulation and modeling; and 8) HF/S must include requirements for specifying system operational performance objectives.

In design and development of ships and ship systems, additional requirements to be imposed on HF/S include: 9) HF/S must provide methods and data to determine manning and to ensure adequate safety and workload; 10) HF/S must address the human-machine interface design requirements specific to a ship acquisition; and 11) HF/S must provide methods and data to identify training and curricula requirements.

1) The primary objective of HF/S is to influence design. The way in which this is accomplished is through several initiatives

- address HF/S issues and concerns early in system acquisition
- define the roles of humans in system operations and maintenance early in system development
- identify deficiencies and lessons learned in baseline comparison systems
- apply simulation and prototyping early in the design process
- apply human-centered design
- apply human-centered test and evaluation.

2) The issue of affordability takes center stage in the HF/S processes due to the importance of manpower, personnel and training as drivers of life cycle costs, and due to the importance of reducing human error, the leading cause of accidents and system failures. The HF/S inputs to the Affordability Assessment include the results of assessments of the implications of HF/S for each candidate Acquisition Strategy and Alternative Design Concept. This analysis involves determination of life cycle resource requirements for: operational and maintenance manpower; training; personnel non-availability due to accident; expected human error rates; expected time to repair; requirements for supportability; and requirements resulting from expected system downtime. The Assessment will define the adjustments required of the proposed acquisition strategy due to HF/S affordability factors; and will recommend changes to the acquisition strategy, or alternative acquisition strategies to resolve problems due to HF/S affordability factors. The Affordability Assessment will assess alternative design concepts on HF/S affordability factors, will identify alternative design concepts having problems with HF/S affordability factors; and will recommend changes to alternative design concepts to improve the performance of HF/S affordability factors.

3) In the realm of Risk Management the HF/S process is focused on efforts to identify, prioritize, and reduce cost risks, schedule risks, design risks, and technology risks. The activities in this realm address reduction of risk, and the conduct of tradeoffs.

HF/S Risk Assessment involves identification of critical human system factors in design alternatives that will have a significant impact on readiness, life cycle costs, schedule, or performance. These include tasks, task sequences, task complexity estimates; environments and environmental controls; equipment design features; maintenance requirements; information requirements; user-computer interface features; manning; workloads; personnel skill levels; training requirements; and hazards.

HF/S tradeoff decisions are required at each milestone. Tradeoffs include: role of the human vs automation; manpower approaches including improved design, task simplification, decision-aiding, automation, or cross-training; design, manning, or training approaches to reduce high drivers; alternative human-machine interface design concepts; hazard elimination, guarding, warning, or training; training vs job aiding; required skill levels of personnel; school house training vs organic training; and training media-fidelity/cost tradeoffs.

4) Concerning the need for maximizing the quality of acquired products, application of the HF/S links the notion of affordability with that of product quality from an HF/S perspective. The underlying concerns in product quality include efforts to ensure usability, reliability, maintainability, supportability, and safety of products, and to improve shipboard quality of life.

5) In concurrent engineering, HF/S ensures that program plans provide for a systems engineering approach to the simultaneous design of the product and its associated manufacturing, test, and support processes. This concurrent engineering approach is viewed as essential to achieving a careful balance among system design requirements (e.g. operational performance, producibility, reliability, maintainability, logistics, human factors engineering, safety, survivability, interoperability, and standardization). HF/S focuses on concurrent engineering through: its integration of human factors engineering, system safety and health, and manpower, personnel and training; its emphasis on supportability considerations in system design; and its reliance on test and evaluation throughout all phases of the HF/S process.

6) Comprehensive evaluation of the human performance and safety impacts associated with the use of commercial and other nondevelopmental items, non-Government standards, and commercial item descriptions. The HF/S process also provides guidance on the application of HF/S methods, techniques and data to the acquisition of nondevelopment items (NDI).

7) The role of prototyping, simulation and modeling in system acquisition is seen mainly as a technique for assessing and reducing risks associated with integrating available and emerging technologies into a system design approach. In the HF/S process, prototyping and simulation serve to ensure that human concerns are addressed early in system acquisition, and also as a technique for reducing developmental costs, thereby enhancing affordability.

8) Performance objectives must satisfy operational needs and be verifiable through testing, and they must include critical supportability factors such as reliability, availability, and maintainability. The major contributions of the HF/S to the achievement of system operational performance objectives include the following:

- identification of design deficiencies and lessons learned in existing systems which adversely impact personnel performance and safety
- development of design, manning and training options to resolve personnel performance, safety and readiness problems identified in existing systems
- determination of the optimum role of the human vs. automation in system operation and maintenance
- development of system, subsystem and component design concepts and criteria
- integration of personnel selection criteria, personnel skill requirements and human performance standards in the development of personnel performance and readiness criteria
- application of standardized, requirements-driven, front-end analysis techniques which address personnel quantity and quality demands as well as human-machine interface design requirements
- determination of manning, workloads, training, and skills and task simplification through HF/S application
- reductions of human error potential and enhancement in error detection and recovery in emerging systems
- reductions in accident rates and health hazards, and enhancement of human performance and safety in adverse environments
- reductions in the risks associated with personnel capability, availability, performance, productivity, and safety;
- attention to development and implementation of HF/S technology
- avoidance/reduction costs associated with reduced error rates, reduced accident rates, reduced system redesign requirements, enhanced system availability, reduced training time and effort, reduced training pipelines, improved system supportability, and increased system survivability.

9) HF/S must provide methods and data to consider workload reduction and to ensure adequate safety and workload. The major approach to reducing workload is to reallocate functions to automated performance that were previously conducted manually. In this strategy, the emphasis is on determining the role of the human in the system. The HF/S approach to role of human determination, is directed at describing, through reverse engineering, the allocation of function strategy evident in an existing system. Alternate allocations are then characterized based on automating manual functions, and the impact of these allocation alternatives on human workload is then measured through task network simulation.

10) HF/S must address the human-machine interface design requirements specific to a ship acquisition. In accomplishing this, the HF/S specialist operates at both the interface level and the system level. At the interface level HF/S is concerned with the design of human-machine interfaces at the point of interface. At the system level, HF/S is concerned with several specific aspects of the system which are provided by the sum total of the interfaces that make up the system. These aspects include:

- system design for operability (reduction of human error potential in operations, provision of decision aids, design to facilitate training, etc.)
- design for maintainability (reduction of human error potential in maintenance, reduced time to repair, increased operational time, etc.)

- design for survivability and safety (design to reduce accidents, design of warning devices and countermeasures, design of protective clothing and equipment)
- design for supportability (design of documentation, design of supply interfaces, etc.)
- design for habitability (environmental design, equipment arrangements, compartmentalization, etc.)
- design for usability (design for ease of use, reduced workload, etc.)
- design to reduce costs (human engineering design for operability design and training requirements).

11) HF/S must provide methods and data to identify training and curricula requirements. The HF/S process recognizes (but does not specifically address) issues and concerns for operator and maintainer training. Within the HF/S process, training considerations both (1) result from requirements analyses and design, and (2) influence system design by being considered within the design tradeoff space. Relevant HF/S issues in terms of training include the following:

- Skill level projection
- Training requirements
- Constraints on training overhead
- Directed training decisions
- Training effectiveness objectives
- Constraints on training equipment and facilities
- Requirements for special skills
- Requirements for new skills
- Constraints on the training pipeline
- Requirements for embedded training
- Requirements for computer assisted instruction
- Requirements for cross training
- Requirements for on-line tutorials/job performance aids
- Requirements for decision aid
- Expected problems with training
- Expected problems with skills

The objective of HF/S is to produce a design concept for the system human-machine interface which reduces the potential for human error and accident and which ensures that the human in the system performs as required. HF/S views the human as an integral component of the system to be interfaced with the hardware, software, informational and environmental elements of the system. The body of knowledge of HF/S encompasses knowledge of human capabilities and limitations, and principles and data addressing the application of this knowledge.

Human Factors/Safety (HF/S) technology. The HF/S process supports design activity by providing methods and data for:
maximizing the quality of acquired products, participating in concurrent engineering, application of commercial standards, using prototyping and
simulation to support the development and assessment of human-machine interface design concepts, and ensuring that performance objectives satisfy operational needs. HF/S is predicated on the technological opportunities associated with:

- defining and designing for the role of the human in complex systems:
  - allocation of function criteria;
  - tools to define the required role of the human (vs automation);
  - data on human performance capability
- using simulation and modeling to:
  - consider alternative function allocation strategies;
  - assess operator workloads;
  - determine human operator/maintainer performance and task models;
- determining workloads:
  - automation of functions;
  - integration of humans and automation;
  - consolidation of functions through data fusion, cross training, collaboration, team performance;
  - simplification of functions through application of human engineering standards, and implementation of decision support systems;
  - elimination of functions through job redesign, telemaintenance, teleoperation;
- knowledge generation: to reduce cognitive workloads on CG personnel, emphasis must be placed on requirements for generation and processing of knowledge as well as information, wherein:
  - all relevant information is integrated, fused, correlated, prioritized, and synthesized into general principles, constituting knowledge;
  - meaning and context are provided to available information to enable the human to understand the situation and be able to formulate strategies for acting on this knowledge;
  - uncertainty is reduced through maximized usage and correlation of all available information.
- advanced human-machine interfaces through human-centered design:
  - advanced displays/workstations;
  - advanced control systems (e.g. voice, gesture);
  - techniques for human/automation interaction (human-centered automation)
  - display aids (e.g. aiming aids, predictor displays, overlays and templates)
  - effective and responsive communications/networks
  - techniques for establishing and maintaining situational awareness and operational perspective;
  - decision support systems, expert systems, knowledge-based systems and intelligent tutoring systems;
  - information management systems interfaces;
  - information security systems interfaces;
  - robotic interfaces;
  - user-computer interfaces (UCI);
  - intelligent diagnostics;
  - criteria for maintenance workspace and accessibility;
  - protective equipment/alarms.
- integrating CG design methods and data;
  - processes to ensure that human operator requirements influence design;
  - methods and models to define and assess arrangements;
  - tradeoff tools;
  - human engineering design and evaluation tools;
  - human engineering interfaces with CAD;
  - 3-D virtual environments for conceptualization of design approaches;
  - hypertext versions of HF/S standards, specifications and databases;
- enhancing productivity
  - electronic documentation;
  - decision support systems;
  - on-line help;
  - office systems;
  - on-line human performance assessment;
- improving the quality of life at work with attention to the quality of services and facilities afforded the crew with respect to habitability, medical care, administrative and personal support, environment control, personal safety, cultural and educational opportunities, and physical security to achieve the objective of reduced life cycle cost with improved crew performance, productivity, and safety. Major areas for consideration in improving quality of life at work include:
  - improved hotel services, including improved privacy, berthing and food service;
  - improved human-machine interfaces and training provisions
  - improved ship-shore electronic interface;
  - improved career progression.